



# Human Factors and Behavioral Performance Exploration Measures Harmonized Across HERA, NEK, and ISS: Behavioral Medicine Risk

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# Human Factors Behavioral Performance (HFBP) Exploration Measures



## HFBP-EM

<b>Physiology/Biomarkers</b>
Sleep
Heart Rate
<b>Individual Behavioral Health</b>
Personality Assessment
Social Desirability
Depression
Mood and Affect
Neurobehavioral Function
<b>Objective Performance</b>
Cognition
ROBoT
<b>Team &amp; Social Dynamics</b>
Team Performance: MCC Ratings
Team Performance: Crew Ratings
Team Cohesion
Team Processes
Psychological Safety
Social Support
Group Living

Blue = Subset of measures administered on the ISS



Human Exploration Research Analog (HERA)



International Space Station (ISS)



Russian Ground Based Experiment Complex (NEK)



# Key Between Campaign Differences

	Campaign Manipulation	Crew	Mission Scenarios	Days in mission	Habitat Size	Off-nominal events
HERA C4	Sleep restriction	5, 4-person crews; American	Travel to asteroid Emergency Event	45	148.6m <sup>3</sup>	Hurricane Harvey: Mission 2 early egress
HERA C5	Reduced privacy and habitable volume	4, 4-person crews; American	Travel to Phobos Emergency Event	45	<148.6m <sup>3</sup>	Covid19: Mission 5 post-mission early termination
NEK-SIRIUS19	Single 24-hr sleep restriction	1, 6-person crew; multinational	Lunar Landing	120	550 m <sup>3</sup>	NA
ISS	N/A	8, 3-11 person crews; multinational	EVA	150-350	388 m <sup>3</sup>	NA



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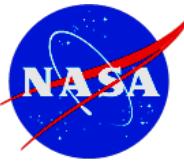


# Harmonization Project Aims

1. Build a Harmonized database of individual and team HFBP-EM data from spaceflight analogs and spaceflight settings
2. Summarize the trajectory of individual and team outcomes within and between mission settings

HFBP-EM Suite	<b>Physiology/Biomarkers</b>
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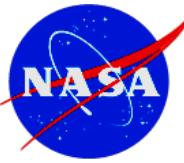


# Presentation Focus

1. Build a Harmonized database of individual and team HFBP-EM data from spaceflight analogs and spaceflight settings
2. Summarize the trajectory of individual and team outcomes within and between research settings

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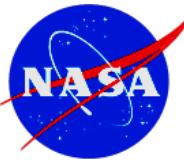
# Harmonization Methodology

1. Define the research question
2. Catalog study characteristics and database content
3. Evaluate harmonization potential of studies
4. Process data under a common format
5. Integrate data
6. Analyze data



# Aim 1 Results - Harmonized Database

	n	Age Mean (SD)	Sex	Education (% advanced degrees)	Military experience n (mean years, SD)	ICE experience n (mean months, SD)
<b>HERA C4</b>	20	39.26 (8.4)	7F   13M	75%	5 (20.6, 13.12)	0 (0, 0)
<b>HERA C5</b>	16	36.96 (5.52)	4F   12M	100%	6 (14.16, 8.08)	2 (12.1, 16.79)
<b>SIRIUS19</b>	6	34.34 (5.13)	3F   3M	100%	2 (15. 7.07)	4 (4.6, 2.98)
<b>ISS</b>	15	45.75 (8.85)	3F   10M	100%	NA	NA
<b>Total</b>	57	39.47 (7.63)	17F   38M	91%	NA	NA



# Aim 2 Results

- Aim 2: Summarize the trajectory of individual outcomes with and between mission settings
- Results for:
  - Sleep
  - Mood
  - Cognitive performance
  - Behavioral performance

# Total Sleep Time Each Mission Day by Research Setting

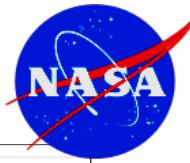
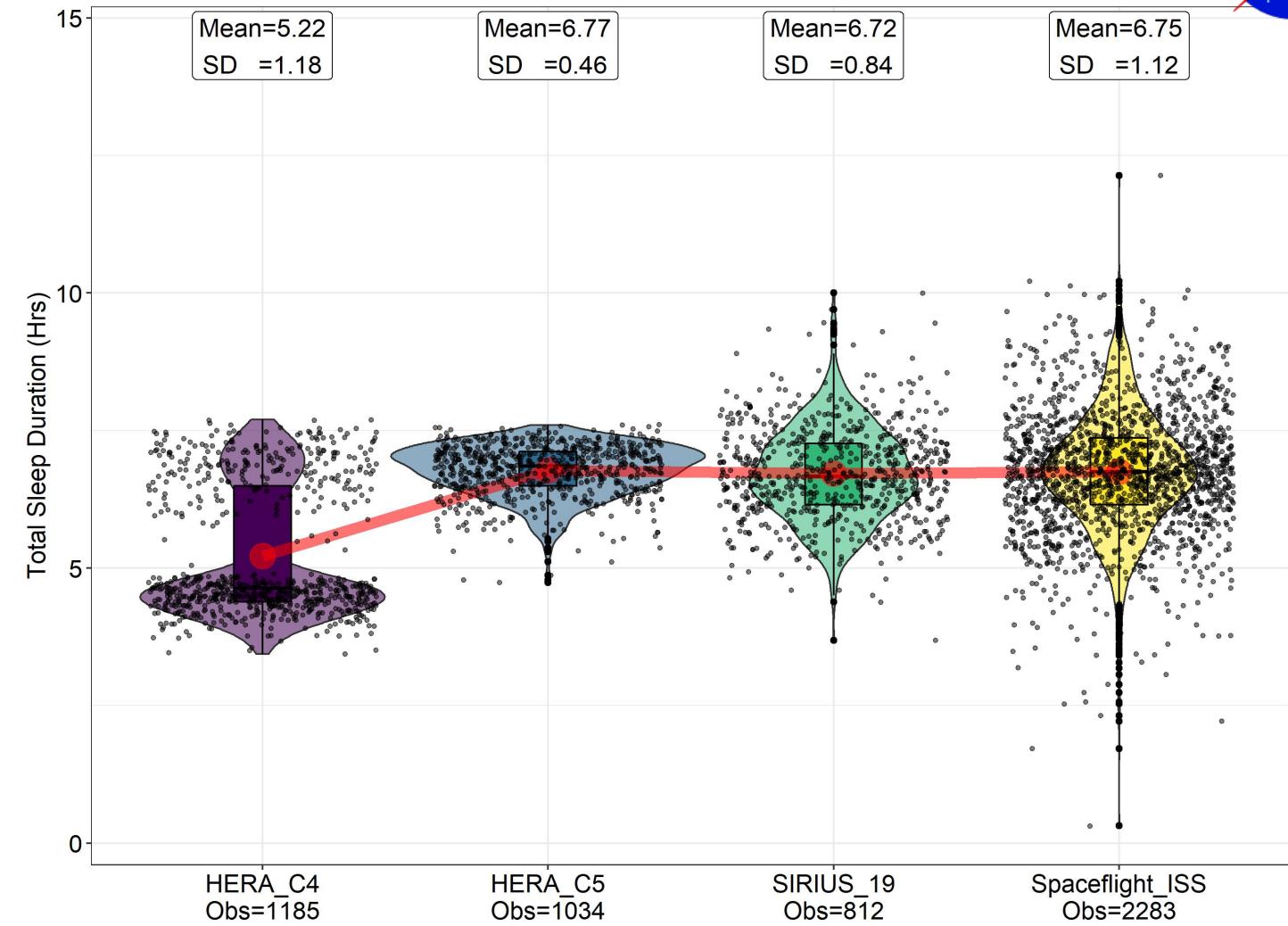


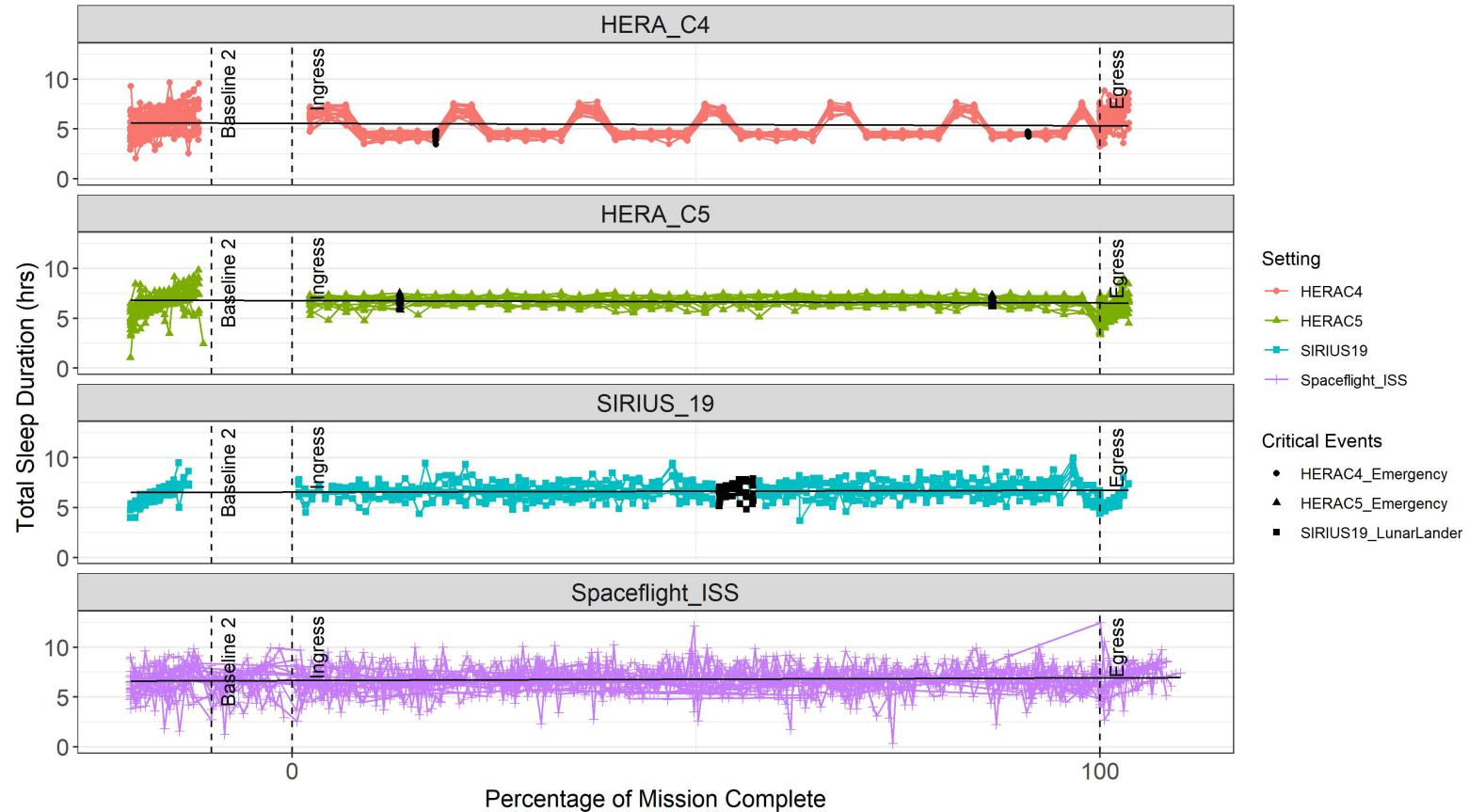
Photo credit: BHP Lab

Actiwatch

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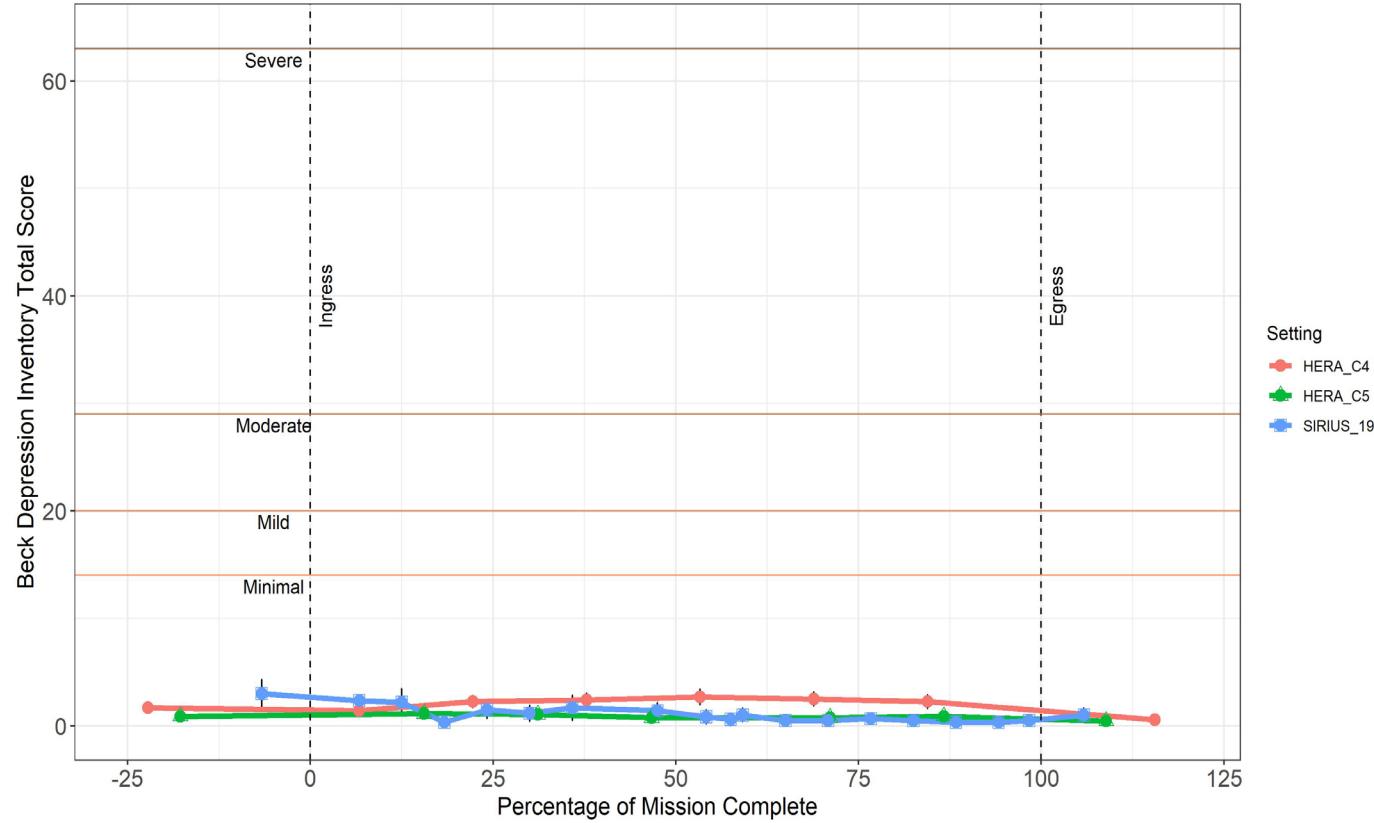
# Total Sleep Time by Research Setting Over Percentage Mission Complete



# Average Depression Symptoms by Research Setting Over Percentage of Mission Complete



- Beck Depression Scale (BDI) administered 1x/week in HERA C4, HERA C5 and SIRIUS19
- Average rating ( $M = 1.38, SD = 1.91$ ) across all three analogs was well below validated clinical cut-offs
- No single individual self-reported symptoms that met or exceeded validated clinical cut-offs (range: 0-9)



Beck et al., 1988

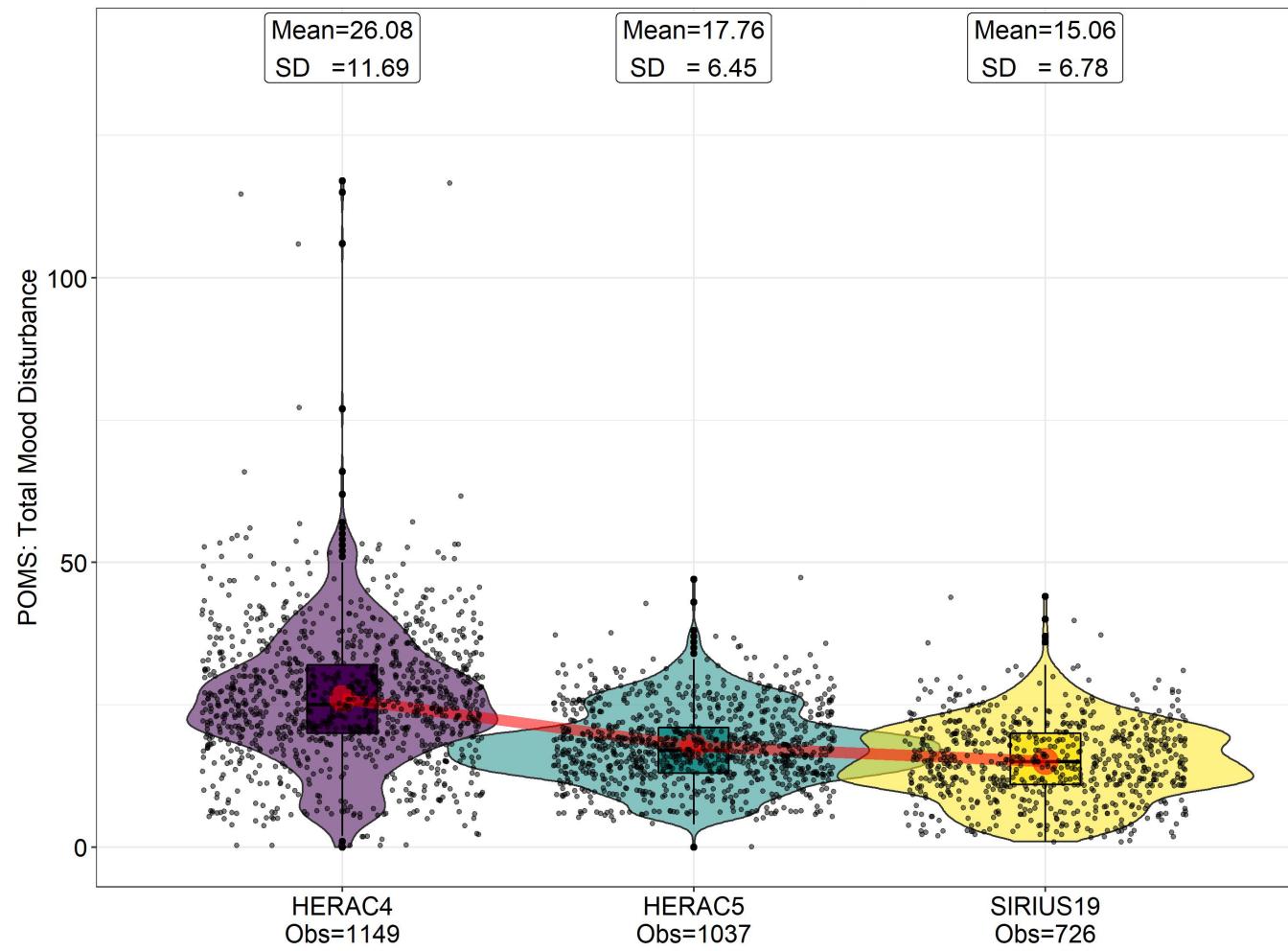
Note: Scale range 1-63. Validated clinical cut-offs displayed with horizontal lines.

# Total Mood Disturbance By Research Setting



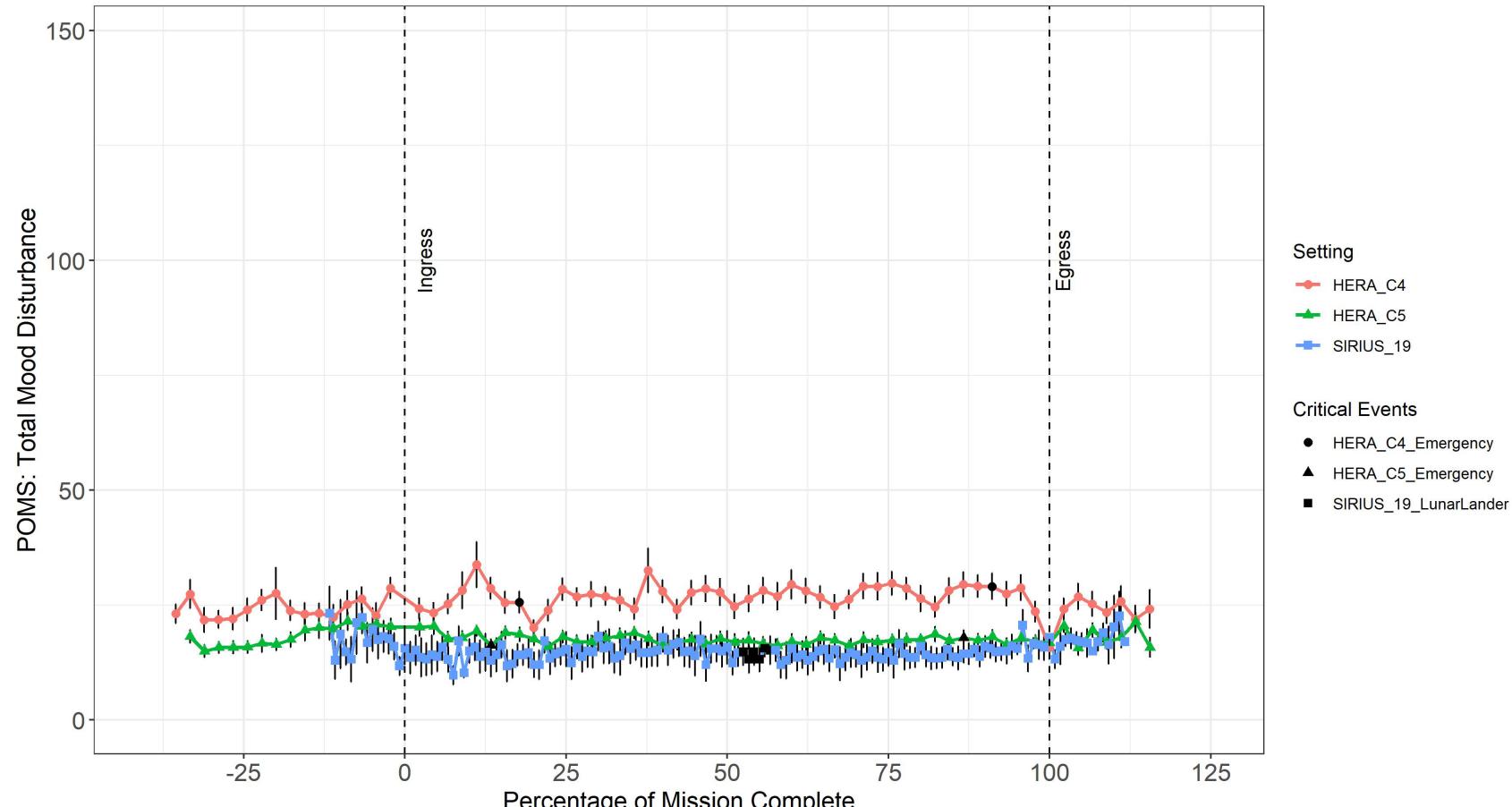
- Profile of Mood States (POMS)

- Anger/hostility
- Confusion/bewilderment
- Depression/dejection
- Fatigue/inertia
- Tension/anxiety
- Vigor/activity
- Total Mood Disturbance



Curran et al., 1995

# Total Mood Disturbance by Research Setting Across Percentage of Mission Complete



Note: Scale ranges from 0 to 148



# Cognitive Performance

- Cognition battery
- 10 subtests, 15 alternate versions
- Administered every 2 days in HERA C4 and C5, every week in SIRIUS19, and 2-3 times in mission on the ISS
- Primary metrics include a speed and accuracy score for each subtests

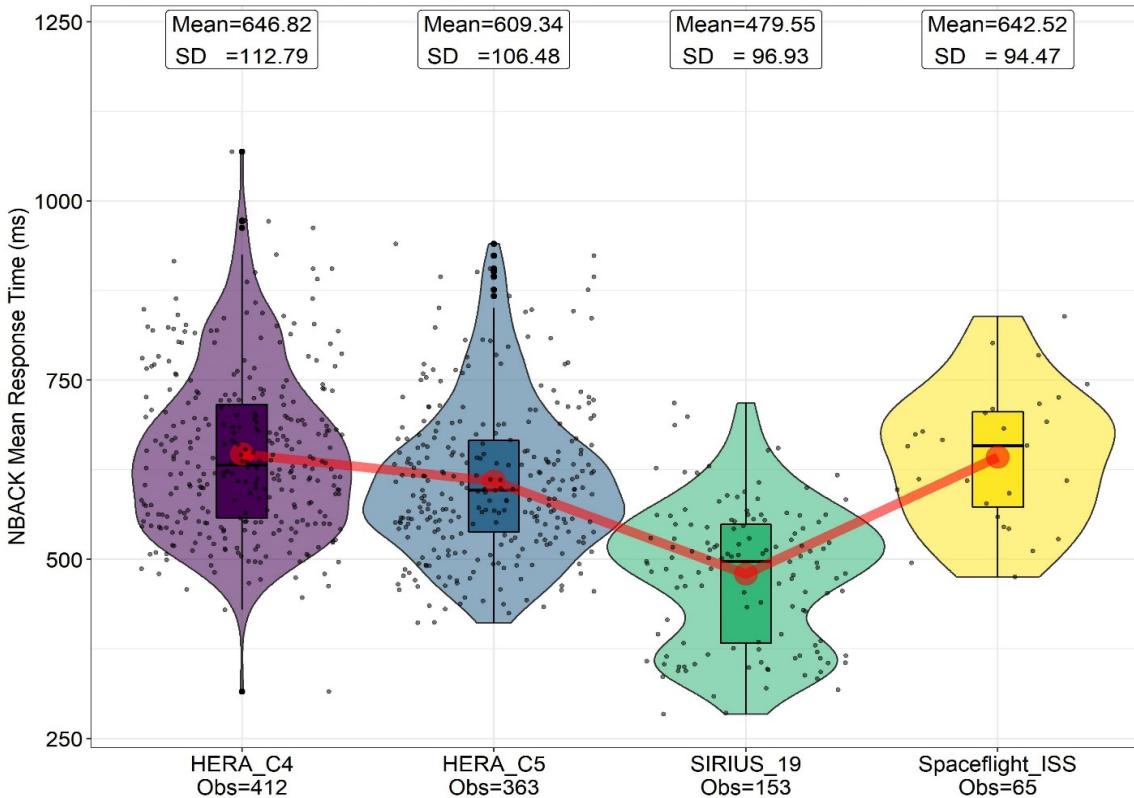
Test	Cognitive Domains Assessed
Motor Praxis	Sensorimotor speed
Visual Object Learning	Spatial learning and working memory
Fractal 2-Back (N-back)	Working memory
Abstract Matching	Abstraction, concept formation
Line Orientation	Spatial orientation
Emotion Recognition	Emotion identification
Matrix Reasoning	Abstract reasoning
Digit Symbol Substitution	Complex scanning and visual tracking
Balloon Analog Risk	Risk decision making
Psychomotor Vigilance	Vigilant attention

Basner et al., 2015

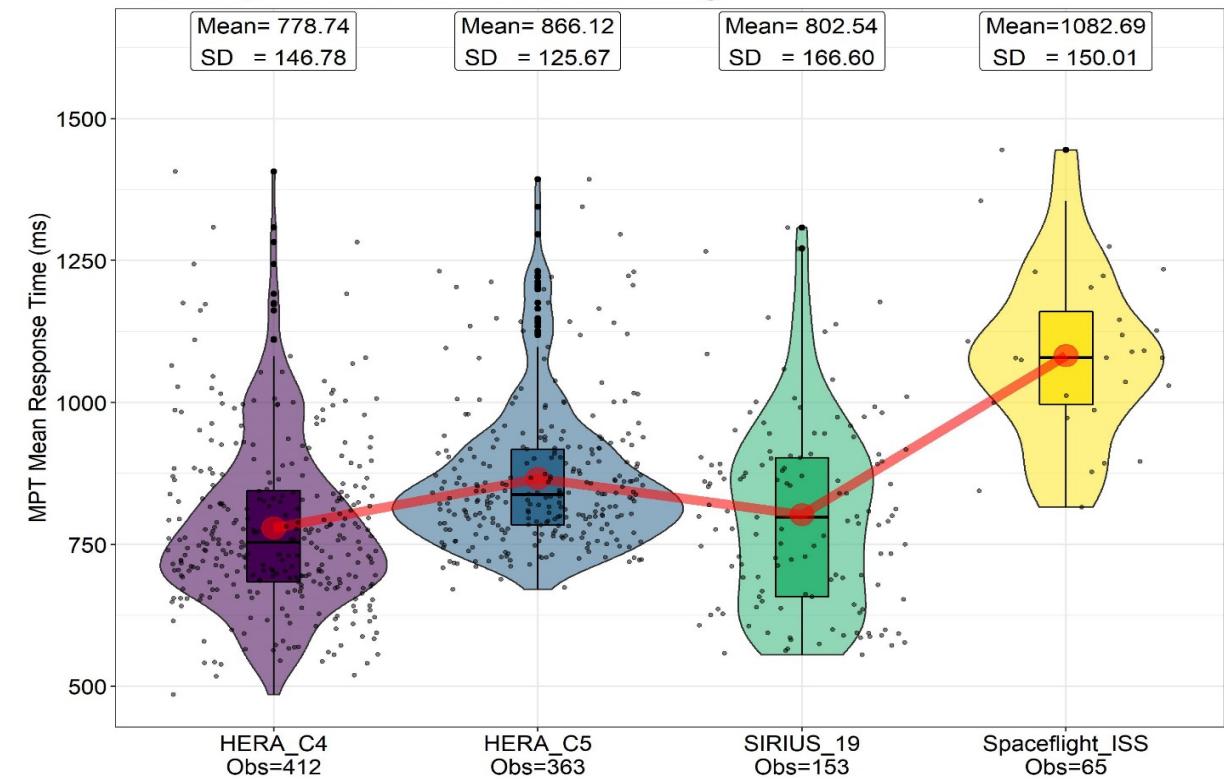


# Cognitive Performance

Cognition N-back Response Time by Research Setting

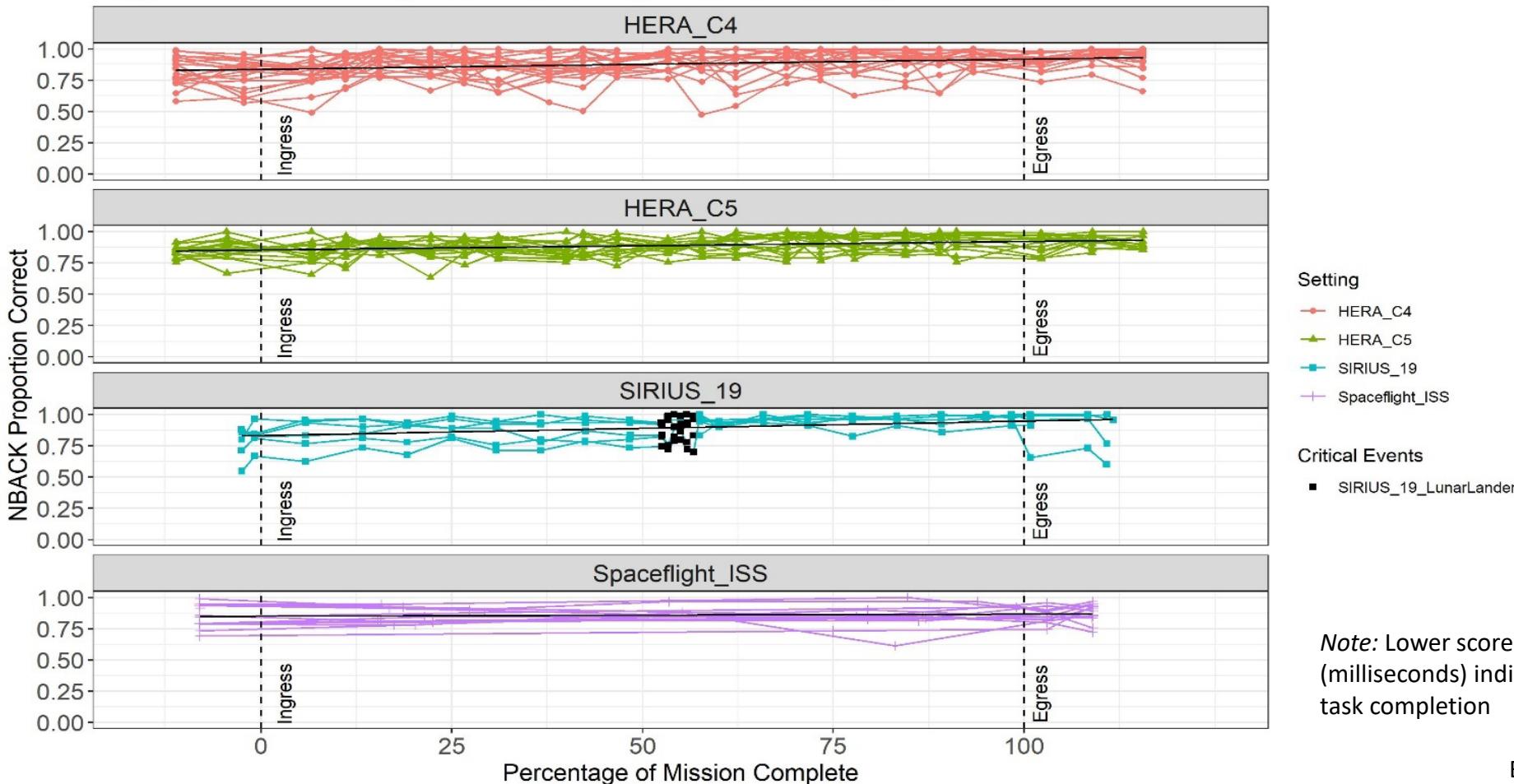
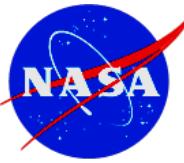


Cognition Motor Praxis Task Response Time by Research Setting



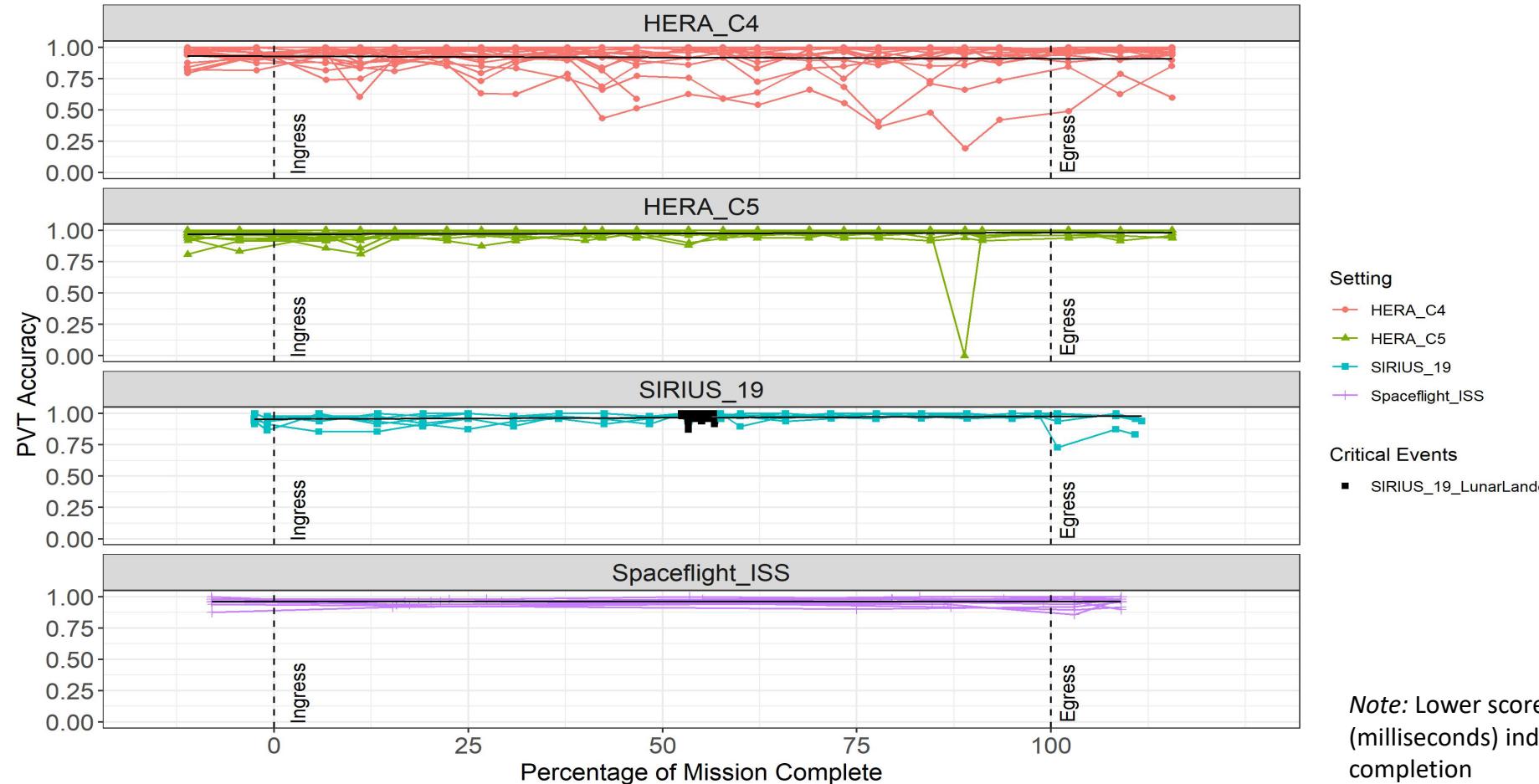
Note: Only in-mission data is represented. Lower scores on the Y-axis (milliseconds) indicates faster task completion

# Cognition: N-back Accuracy Score by Research Setting Across Time



Basner et al., 2020

# Cognition: PVT Accuracy Score by Research Setting Over Time



# Performance: R0BoT-r

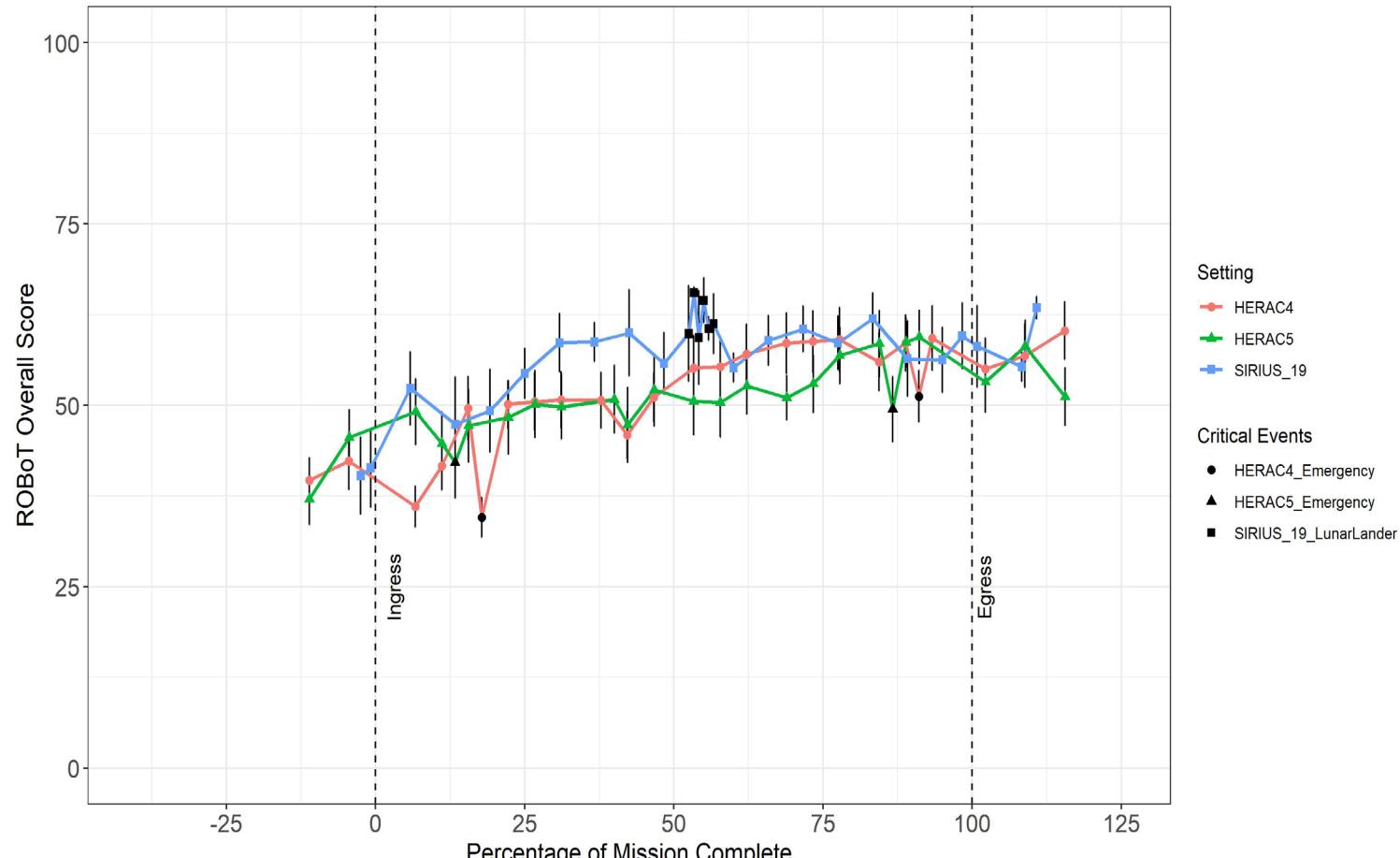
- Research adaptation of an astronaut training simulation of Candarm2 docking procedures on the ISS
- Administered every two days in HERA C4 and C5 and 1x/week on SIRIUS19
- Primary outcome metrics include speed, approach accuracy, and overall score



Astronaut Shane Kimbrough on the ISS  
Photo credit: NASA

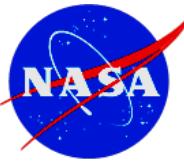
Ivkovic et al., 2019

# Performance: R0BoT-r Overall Score by Research Setting Across Time



Note: Higher scores on the Y-axis indicate better performance. Score ranges from 0 to 100.

# HFBP-EM Harmonized Data Set Key Findings

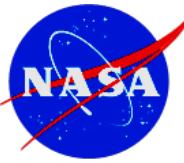


- ISS crewmembers were most similar to HERA C5 and SIRIUS19 in average sleep duration
- Sleep deprivation condition (HERA C4) associated with:
  - Increased psychological distress, particularly fatigue/inertia and mental fatigue
  - Worse performance over time on tasks of vigilant attention and spatial orientation only
  - No distinct effects on operationally relevant performance task (ROBoT-r)
- Minimal symptoms of depression reported
- Critical event of lunar landing was associated with performance changes in ROBoT-r and Cognition in SIRIUS19, but not with changes in sleep or ratings of mood and affect



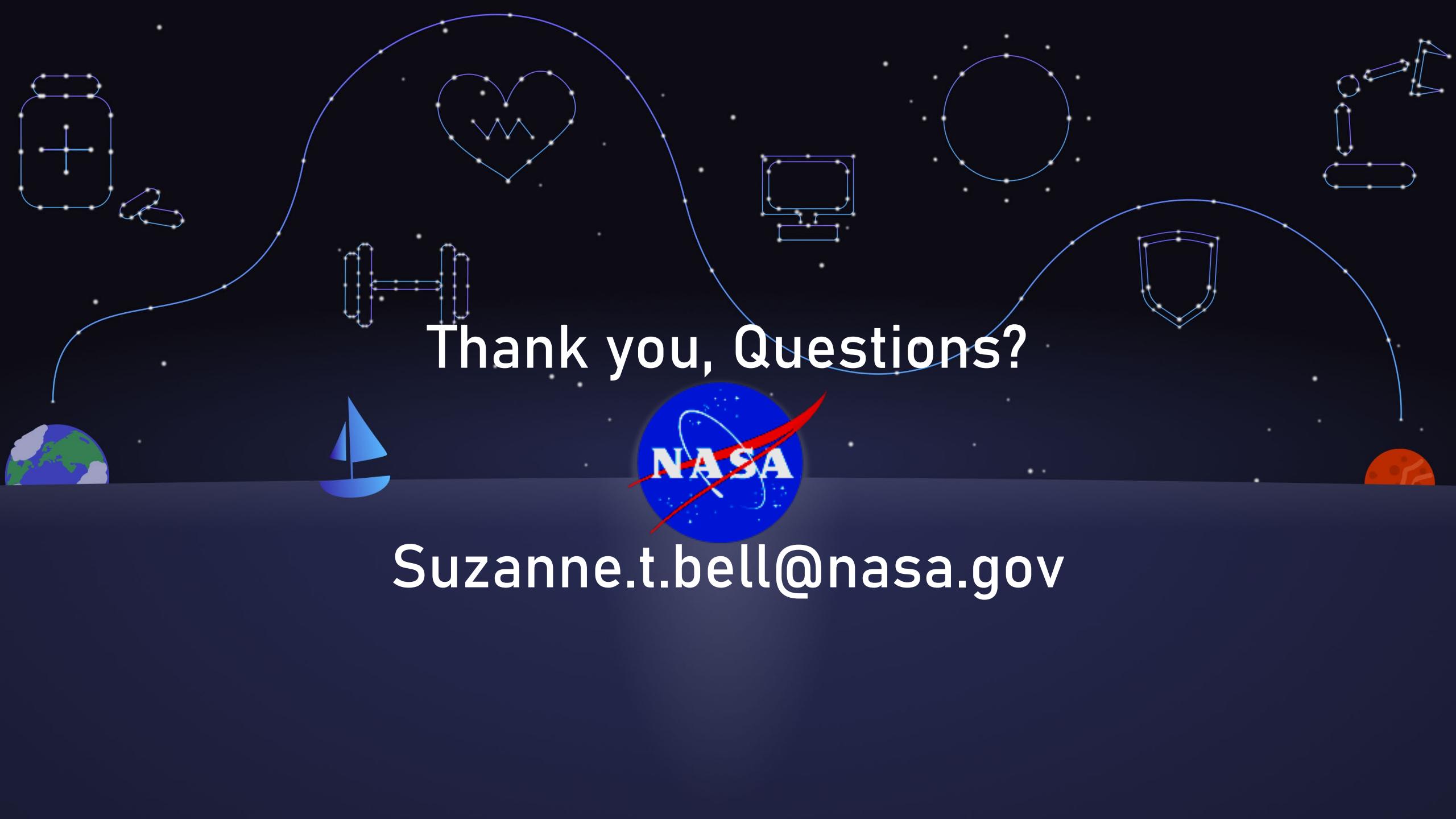
# Next Steps

- Advanced statistical modeling
  - Characterize HRP behavioral medicine, team, sleep, and some HSIA risk gaps
  - Identify HRP risk mitigation strategies in long duration spaceflight
- Data collaboration
- Normative datasets to identify operationally relevant thresholds (i.e., norms)
- Integrated into a user-friendly dashboard for real-time decision making



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Thank you, Questions?



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